

Claims

- [c1] 1. A retract circuit for retracting a data transducer carriage assembly of a mass data storage device to a retracted position, comprising:
 - a digital state machine;
 - said digital state machine being user programmable to operate in a selected retract mode;
 - and an analog control circuit for receiving control signals from said digital state machine for providing analog retract signals to move said data transducer carriage assembly.
- [c2] 2. The retract circuit of claim 1 further comprising an analog driver to receive control signals from said digital state machine, said analog driver having a programmable gain.
- [c3] 3. The retract circuit of claim 1 wherein said digital state machine is user programmable to operate in constant voltage, velocity detect, float and pulse, and crash stop detect modes.
- [c4] 4. The retract circuit of claim 1 wherein said digital state machine is programmed to detect a velocity of said data

transducer carriage assembly.

- [c5] 5. The retract circuit of claim 4 wherein said digital state machine is programmed to detect an error velocity of said data transducer carriage assembly from a difference of a measured voltage across said data transducer driver from a predetermined voltage.
- [c6] 6. The retract circuit of claim 5 wherein said predetermined voltage is user programmable.
- [c7] 7. The retract circuit of claim 5 wherein said predetermined voltage is user programmable to a resolution of two bits.
- [c8] 8. The retract circuit of claim 5 wherein said predetermined voltage is user programmable to a resolution of more than two bits.
- [c9] 9. A retract circuit for retracting a data transducer carriage assembly of a mass data storage device to a retracted position, comprising:
means for establishing a digital state machine;
said means for establishing a digital state machine being user programmable to operate in a selected retract mode;
and means for establishing an analog control circuit for receiving control signals from said means for establish-

ing a digital state machine for providing analog retract signals to move said data transducer carriage assembly.

- [c10] 10. The retract circuit of claim 9 further comprising means for establishing an analog driver to receive control signals from said means for establishing digital state machine, said means for establishing analog driver having a programmable gain.
- [c11] 11. The retract circuit of claim 9 wherein said means for establishing digital state machine is user programmable to operate in constant voltage, velocity detect, float and pulse, and crash stop detect modes.
- [c12] 12. The retract circuit of claim 9 wherein said means for establishing digital state machine is programmed to detect a velocity of said data transducer carriage assembly.
- [c13] 13. The retract circuit of claim 12 wherein said means for establishing digital state machine is programmed to detect an error velocity of said data transducer carriage assembly from a difference of a measured voltage across said data transducer driver from a predetermined voltage.
- [c14] 14. The retract circuit of claim 13 wherein said predetermined voltage is user programmable.

- [c15] 15. The retract circuit of claim 13 wherein said predetermined voltage is user programmable to a resolution of two bits.
- [c16] 16. The retract circuit of claim 13 wherein said predetermined voltage is user programmable to a resolution of more than two bits.
- [c17] 17. A mass data storage device, comprising:
 - a retract circuit for retracting a data transducer carriage assembly of a mass data storage device to a retracted position, including
 - a digital state machine;
 - said digital state machine being user programmable to operate in a selected retract mode;
 - and an analog control circuit for receiving control signals from said digital state machine for providing analog retract signals to move said data transducer carriage assembly.
- [c18] 18. The mass data storage device of claim 17 further comprising an analog driver to receive control signals from said digital state machine, said analog driver having a programmable gain.
- [c19] 19. The mass data storage device of claim 17 wherein said digital state machine is user programmable to oper-

ate in constant voltage, velocity detect, float and pulse, and crash stop detect modes.

- [c20] 20. The mass data storage device of claim 17 wherein said digital state machine is programmed to detect a velocity of said data transducer carriage assembly.
- [c21] 21. The mass data storage device of claim 20 wherein said digital state machine is programmed to detect an error velocity of said data transducer carriage assembly from a difference of a measured voltage across said data transducer driver from a predetermined voltage.
- [c22] 22. The mass data storage device of claim 21 wherein said predetermined voltage is user programmable.
- [c23] 23. The mass data storage device of claim 21 wherein said predetermined voltage is user programmable to a resolution of two bits.
- [c24] 24. The mass data storage device of claim 21 wherein said predetermined voltage is user programmable to a resolution of more than two bits.
- [c25] 25. A method for retracting a data transducer carriage assembly of a mass data storage device to a retracted position, comprising:
providing a user programmable digital state machine to

operate in a selected retract mode;
and providing analog control circuit in response to signals provided by said digital state machine for providing analog retract signals to said data transducer carriage assembly.

- [c26] 26. The method of claim 25 further comprising providing an analog driver having a programmable gain to receive control signals from said digital state machine.
- [c27] 27. The method of claim 25 wherein said providing a digital state machine comprises providing a digital state machine that is user programmable to operate in constant voltage, velocity detect, float and pulse, and crash stop detect modes.
- [c28] 28. The method of claim 25 wherein said providing a digital state machine comprises providing a digital state machine that is programmed to detect a velocity of said data transducer carriage assembly.
- [c29] 29. The method of claim 25 wherein said providing a digital state machine comprises providing a digital state machine that is programmed to detect an error velocity of said data transducer carriage assembly from a difference of a measured voltage across said data transducer driver from a predetermined voltage.

- [c30] 30. The method of claim 29 wherein said predetermined voltage is user programmable.
- [c31] 31. The method of claim 29 wherein said predetermined voltage is user programmable to a resolution of two bits.
- [c32] 32. The method of claim 29 wherein said predetermined voltage is user programmable to a resolution of more than two bits.
- [c33] 33. A retract system for retracting a head assembly in a hard disk drive, comprising:
 - means for measuring a velocity of a voice coil motor (VCM),
 - means responsive to a velocity measurement for establishing a retract voltage;
 - and means for applying said retract voltage to said VCM.
- [c34] 34. The retract system of claim 33 further comprising:
 - a digital processor for configuring said means for measuring, means for establishing a retract voltage, and means for applying said retract voltage to operate in a plurality of operating modes.
- [c35] 35. The retract system of claim 33 further comprising means for operating said hard disk drive in one of a plurality of selectable operating modes.

- [c36] 36. The retract system of claim 35 wherein said means for operating said hard disk drive in one of a plurality of selectable operating modes comprises means for operating said hard disk drive in a constant voltage mode in which a constant retract voltage is applied to said voice coil motor when a retract signal is enabled.
- [c37] 37. The retract system of claim 35 wherein said means for operating said hard disk drive in one of a plurality of selectable operating modes comprises means for operating said hard disk drive in a velocity detect mode in which drive signals are removed from said voice coil motor, a velocity of said head assembly is determined, and an appropriate constant retract voltage is applied to said voice coil motor.
- [c38] 38. The retract system of claim 35 wherein said means for operating said hard disk drive in one of a plurality of selectable operating modes comprises means for operating said hard disk drive in a a float and pulse mode in which drive signals are removed from said voice coil motor, and a repeating pulse is applied a predetermined number of times.
- [c39] 39. The retract system of claim 38 in which the repeating pulse is applied 32 times.

[c40] 40. The retract system of claim 35 wherein said means for operating said hard disk drive in one of a plurality of selectable operating modes comprises means for operating said hard disk drive in a crash-stop-detect mode in which a condition in which said head assembly is against crash the stop is detected, and a constant voltage is applied to hold said head assembly thereagainst.

[c41] 41. In a hard disk drive, a system for moving a head assembly to a retract position, a position of said head assembly being controlled by a voice coil motor, comprising:
an analog section connected to said voice coil motor to apply controllable drive voltages thereto to selectively position said head assembly;
and a digital section connected to receive signals from said analog section and said hard disk drive that reflect operating conditions of said hard disk drive, said digital section including:
a digital state machine defining a number of operating states, said digital state machine moving from state to state in response to conditions in said hard disk drive, and operating to produce digital command signals including a retract command to control said analog section to move said head assembly to said retract position,
and a decoder and digital to analog converter to decode

said digital command signals and convert said digital command signals to analog signals for controlling said analog section.

- [c42] 42. The retract system of claim 41 wherein said digital state machine includes states to determine a current velocity of said head assembly and to produce command signals to said analog section to command said analog section to apply a retract voltage related to said current velocity to said voice coil motor.
- [c43] 43. The retract system of claim 41 wherein said digital section contains a digital processor connected to configure said state machine to operate in one of a number of operating modes.
- [c44] 44. The retract system of claim 43 wherein said operating modes includes a constant voltage mode in which a constant retract voltage is applied to said voice coil motor when a retract signal is enabled.
- [c45] 45. The retract system of claim 43 wherein said operating modes includes a velocity detect mode in which drive signals are removed from said voice coil motor, a velocity of said head assembly is determined, and an appropriate constant retract voltage is applied to said voice coil motor.

- [c46] 46. The retract system of claim 43 wherein said operating modes includes a float and pulse mode in which drive signals are removed from said voice coil motor, and a repeating pulse is applied a predetermined number of times.
- [c47] 47. This retract system of claim 46 in which the repeating pulse is applied 32 times.
- [c48] 48. The retract system of claim 43 wherein said operating modes includes a crash-stop-detect mode in which a condition in which said head assembly is against crash the stop is detected, and a constant voltage is applied to hold said head assembly thereagainst.
- [c49] 49. A method for retracting a head assembly in a hard disk drive, comprising the steps for:
measuring a velocity of a voice coil motor (VCM) to determine a measured velocity,
establishing a retract voltage responsive to said measured velocity;
and applying said retract voltage to said VCM.
- [c50] 50. The method of claim 49 further comprising operating said hard disk drive in one of a plurality of selectable operating modes.

- [c51] 51. The method of claim 50 wherein said operating said hard disk drive in one of a plurality of selectable operating modes comprises operating said hard disk drive in a constant voltage mode in which a constant retract voltage is applied to said voice coil motor when a retract signal is enabled.
- [c52] 52. The method of claim 50 wherein said operating said hard disk drive in one of a plurality of selectable operating modes comprises operating said hard disk drive in a velocity detect mode in which drive signals are removed from said voice coil motor, a velocity of said head assembly is determined, and an appropriate constant retract voltage is applied to said voice coil motor.
- [c53] 53. The method of claim 50 wherein said operating said hard disk drive in one of a plurality of selectable operating modes comprises operating said hard disk drive in a float and pulse mode in which drive signals are removed from said voice coil motor, and a repeating pulse is applied a predetermined number of times.
- [c54] 54. The method of claim 53 in which the repeating pulse is applied 32 times.
- [c55] 55. The method of claim 50 wherein said operating said hard disk drive in one of a plurality of selectable operat-

ing modes comprises operating said hard disk drive in a crash-stop-detect mode in which a condition in which said head assembly is against crash the stop is detected, and a constant voltage is applied to hold said head assembly thereagainst.